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REPORT DOCUMENTATION PAGE

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1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE 02 Sep 97	3. REPORT TYPE AND DATES COVERED Final Tech Report, 01 Dec 93 - 31 May 97
4. TITLE AND SUBTITLE Modeling and Visualization for Polymers, Surfaces and Biomolecules			5. FUNDING NUMBERS F49620-94-1-0080
6. AUTHOR(S) Professor Chandrajit L. Bajaj			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Purdue University W. Lafayette IN			8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) AFOSR/NM 110 Duncan Avenue Suite B115 Bolling AFB DC 20332-8050			10. SPONSORING/MONITORING AGENCY REPORT NUMBER
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION AVAILABILITY STATEMENT Distribution Unlimited.			12b. DISTRIBUTION CODE
13. ABSTRACT (Maximum 200 words) Distributed data filtering algorithms for automatically reconstructing scalar fields such as potential energy surfaces have been developed. DTIC QUALITY INSPECTED 2			
14. SUBJECT TERMS Polymers, biomolecules, graphical simulation			15. NUMBER OF PAGES 4
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL

19980115 209

Final Technical Progress Report
(01 September 96 - 31 May 97)

Project Title: Modeling and Visualization for Polymers, Surfaces
and Biomolecules

PI Name (Last, First, MI): Bajaj, Chandrajit, L.

Institution: Purdue University 2304/DS

Contract/Grant No. F49620-94-1-0080 NM

and F49620-93-1-0553 (Aasert) NX NM (AASERT Supplement)

SUMMARY OF RESEARCH OBJECTIVES

Our research emphasizes efficient algorithms and data structures for biomolecular modeling and visualization.

The main research thrusts of this contract are:

1. The computation of the topological, combinatorial and metric properties of the molecular structure of polymers and biomolecules based on weighted α shapes
2. The determination of similarities between two or more polymers or biomolecules based on geometric matching of the determined structural properties of the molecules
3. The development and graphical simulation of localized molecular docking strategies based on road map calculations on convolution surfaces of the interacting molecule structures and localized regions of the potential energy surfaces
4. The modeling, visualization and manipulation of the molecules together with their potential energy surfaces.
5. The implementation of the above algorithms in an existing distributed (multi-user and multi-workstation) geometric software environment.

SUMMARY OF TECHNICAL PROGRESS

1. In our quest for real-time, interactive modeling and visualization of polymers, biomolecules, and associated scalar fields we have developed and implemented scattered data fitting algorithms in our SHASTRA distributed and collaborative software environment. The implementation is fully distributed, harnessing the collective power of networked workstations. It is capable of automatically reconstructing (accurately and smoothly) the union of balls structures as well as scalar fields such as electron density and potential energy surfaces.

This research is reported in publications 1, 2, 4, 5 and 6 below.

2. The AASERT supplement to the grant supported graduate students Susan Evans and Dan Schikore. Together with Susan and Dan we studied problems in molecular surfaces (arbitrary topology) using different

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spline representations. Furthermore we analyze the suitability of these patch representations for visualizing scalar functions such as molecular orbitals and potential interaction energies.

This research has resulted in publications 3, 7, 8 below.

12. a. Number of AFOSR supported:

- i. Papers published or accepted for publication in refereed journals: 1
- ii. Papers published or accepted for publication in refereed conferences: 4
- iii. Books or book chapters published or in press: 3

b. Trainee Data: Total 8 Female 2 Male 6
 Minority 0 Non Us Citizen 5

- i. No. of Grad Students 6
- ii. No. of Postdoctorals 0
- iii. No. of Undergraduates 1

d. Awards/Honors to PI and/or members of PI's research group (please describe).

Awarded Visualization Chair, The University of Texas at Austin, Austin, TX.

Appointed Director of the Visualization Research Center with the Texas Institute of Computational and Applied Mathematics (TICAM), The University of Texas at Austin.

e. Brief description of all transitions (or intended transitions) of your ideas or techniques to industry, to military laboratories or to military application.

We have been collaborating with WPAFB, (Ruth Pachter) on our molecular modeling, docking and similarity computations. We provided our alpha shapes modeling and visualization software to Ruth and her group to enable them to visualize molecular surfaces and properties (using our A-splines) for siloxane polymers with NLO moieties. This visualization shall be coupled to the GROPE system which WPAFB has recently acquired.

Additionally, we plan to transition Dynamic Mesh Simplification, Compression and Visualization Techniques to the Institute of Defense Analysis, Arlington, VA.

g. Attach list of papers and other publications with full citation.

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[1] "Rational Parameterizations of Nonsingular Cubic Surfaces",
(with R. Holt and A. Netravali).

Full version accepted for publication in {ACM Transactions on Graphics}, (1997).

[2] Book: {\sf Scientific Visualization Techniques}, John Wiley and Sons, (1997).

[3] ``Splines and Geometric Modeling",
(with S. Evans)
{CRC Handbook of Discrete and Computational Geometry},
edited by J. Goodman and J. O'Rourke,
CRC Series, {Discrete and Combinatorial Mathematics},
(1997), 833 - 849.

[4] Book Chapter: ``Implicit Surface Patches",
{Introduction to Implicit Surfaces}, edited by J. Bloomenthal,
{Morgan Kaufman Publishers}, (1997), 98 - 125.

[5] ``Interrogative Data Visualization",
(Invited Paper at the 7th IMA Conference on the Mathematics of Surfaces),
{The Mathematics of Surfaces VII},
edited by T.N.T. Goodman and R. Martin, {Oxford University Press},
(1997).

[6] ``NURBS based B-rep Models for Macromolecules and their Properties",
(with H-Y. Lee, R. Merkert, V. Pascucci),
{Proc. of the 1997 ACM Symposium on Solid Modeling},
ACM Press, (1997), Atlanta, Georgia, 217 - 228.

[7] ``Contour Trees and Small Seed Sets for Isosurface Traversal",
(with M. van Kreveld, R. van Oostrum, V. Pascucci, D. Schikore)
{Proc. of the 13th Annual ACM Symposium on Computational Geometry},
ACM Press, (1997), Nice, France, 212 - 219.

[8] ``The Contour Spectrum",
(with V. Pascucci, D. Schikore)
{Proc. of the Annual IEEE Visualization Conference},
IEEE Computer Society Press, (1997), Phoenix, Arizona.

h. List of Invited Presentations

Dagstuhl-Seminar on Scientific Visualization, Schloss Dagstuhl,
West Germany, May 1997.

Minisymposium on Reverse Engineering,
Conference on Computer Aided Geometric Design, Lillehammer, Norway,
July 1997.

IMACS conference on Problem Solving Environments
Berlin, Germany, August 1997.

Invited Speaker at the Laredo Course on Applications of Symbolic Computing, Laredo, Spain, September 1997.

Invited Speaker for a Tutorial at Eurographics '97, Budapest, Hungary, September 1997.

Invited Speaker for the Conference on New Themes in Computer Aided Geometric Modeling, Tel-Aviv, Israel, February 1998

Invited Speaker at the Mathematisches Forschungsinstitut Oberwolfach Seminar on Free-Form Curves and Surfaces, West Germany, June 1998.

i. List of Program Committees Served

Pacific Graphics '97, Korea, 1997

Computer Graphics International '97, Belgium, 1997.

Workshop on Algorithms and Data Structures '97, WADS, Halifax, Canada 1997.

Program Committee Member of the IEEE Visualization Conference '97, Phoenix, Arizona, October 1997.

Program Committee Member of Fifth International Conference on Computer-Aided Design and Computer Graphics, Shenzhen, China, December 1997.

Program Committee Member of the ACM symposium on Computational Geometry (Theory) Minneapolis, MN, June 1998.

Program Committee Member of IMA Math of Surfaces VIII, Birmingham, UK, August 1998.